

Barnegat Bay Research 2011 - 2015

Joseph Bilinski

**Division of Science, Research, and Environmental Health
New Jersey Department of Environmental Protection**

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NJ Water Monitoring Council



Barnegat Bay Research: Is the Ecological Health of the Bay in Decline?

- Extensive historical research, but projects not fully coordinated – Data Gaps
- Need to know the extent of impacts and determine the sources
- Citizen concerns:
 - Sea nettles
 - algal blooms
 - loss of habitat
 - declining clam/crab catch

Governor's Comprehensive Plan of Action: 10 Point Plan

<http://www.nj.gov/dep/barnegatbay/>

1. Close Oyster Creek Nuclear Power Plant
2. Fund Stormwater Runoff Mitigation Projects
3. Reduce Nutrient Pollution from Fertilizer
4. Require Post-Construction Soil Restoration
5. Acquire Land in the Watershed
6. Establish a Special Area Management Plan
7. Adopt More Rigorous Water Quality Standards
8. Educate the Public
- 9. Fill in the Gaps on Research**
10. Reduce Water Craft Impacts

Plan 9: Comprehensive Research – 3 Years/10 Projects/\$3.75 M



GOALS: Produce More Comprehensive Research to:

- Support water quality improvement (nutrient criteria)
- Establish the baseline conditions of the bay
- Fill in critical data gaps
- Advance habitat restoration on the Bay
- Provide data to address management questions

Support for Other Plans (7, 8 and 10)

Status: COMPLETE!

- Years 1 & 2 Reports Posted (<http://nj.gov/dep/dsr/barnegat/final-reports/>)
- Year 3 Final Reports (posted soon)

BARNEGAT BAY COMPREHENSIVE RESEARCH – OBJECTIVES *

	BBay Research Projects	Bio-Criteria	Water Quality Model	Power Plant	Tourism & Recreation	Food Safety	Comprehensive/ Baseline/Data Gaps
1	Benthic Invertebrate Community Monitoring and Indicator Development for Barnegat Bay	X	X	X			X
2	Algal Diatoms as Environmental Indicators in Barnegat Bay	X	X				X
3	Assessment of Hard Clam in Barnegat Bay			X	X	X	X
4	Assessment of Fishes and Crabs Responses to Human Alteration of Barnegat Bay			X	X		X
5	Assessment of the Distribution and Abundance of Stinging Sea Nettles (Jellyfishes) in Barnegat Bay			X	X		X
6	Baseline Characterization of Phytoplankton Communities and Harmful Algal Blooms (HABs)	X	X		X	X	X
7	Baseline Characterization of Zooplankton Communities			X			X
8	Multi-Trophic Level Modeling of Barnegat Bay			X	X		X
9	Tidal Freshwater and Salt Marsh Wetland Studies of Changing Ecological Function and Adaptation Strategies		X		X		X
10	Ecological Evaluation of Sedge Island Marine Conservation Area in Barnegat Bay				X		X

* BARNEGAT BAY PROSPECTUS: MONITORING, ASSESSMENT, AND RESEARCH PRIORITIES FOR THE BARNEGAT BAY-LITTLE EGG HARBOR ECOSYSTEM TO SUPPORT SCIENCE-BASED WATERSHED MANAGEMENT SEPTEMBER 24, 2010 By: Barnegat Bay Partnership STAC http://www.nj.gov/dep/barnegatbay/docs/bbp_prospectus20100924.pdf

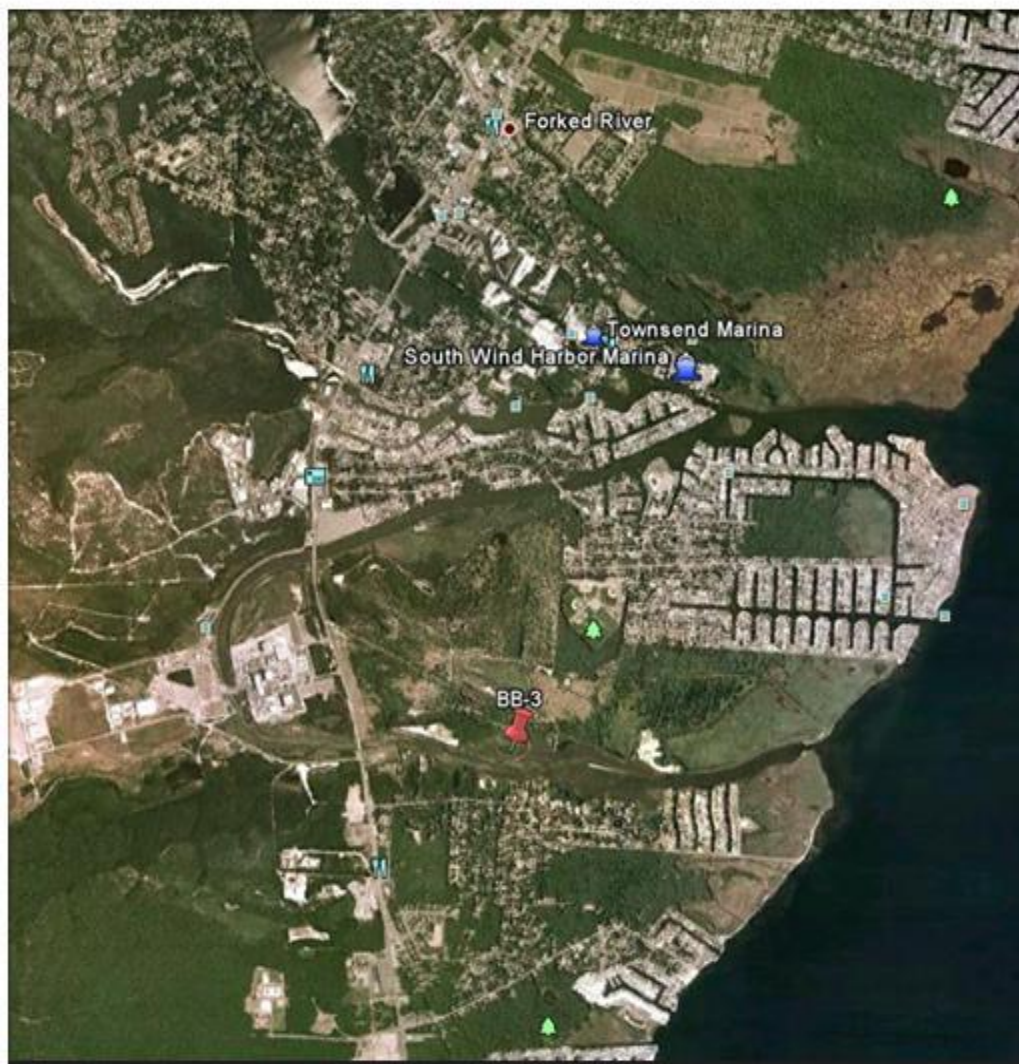
WHY RESEARCH?

To understand, separate out effects, and manage human impacts to Barnegat Bay

1. Eutrophication (Harmful Algal Blooms, Low DO)
2. Power Plant Operation (Impingement, Entrainment, Thermal Discharges)
3. Habitat Loss and Alteration
4. Storm Water Run-off
5. Hardened Shorelines/Reduced Biodiversity
6. Invasive Species
7. Boating and Jet Skis
8. Marina Operations (Oil, solvents, anti-fouling paint)
9. Climate Change/Sea-Level Rise
10. Pollution (Chemical, Trash/Floatables)



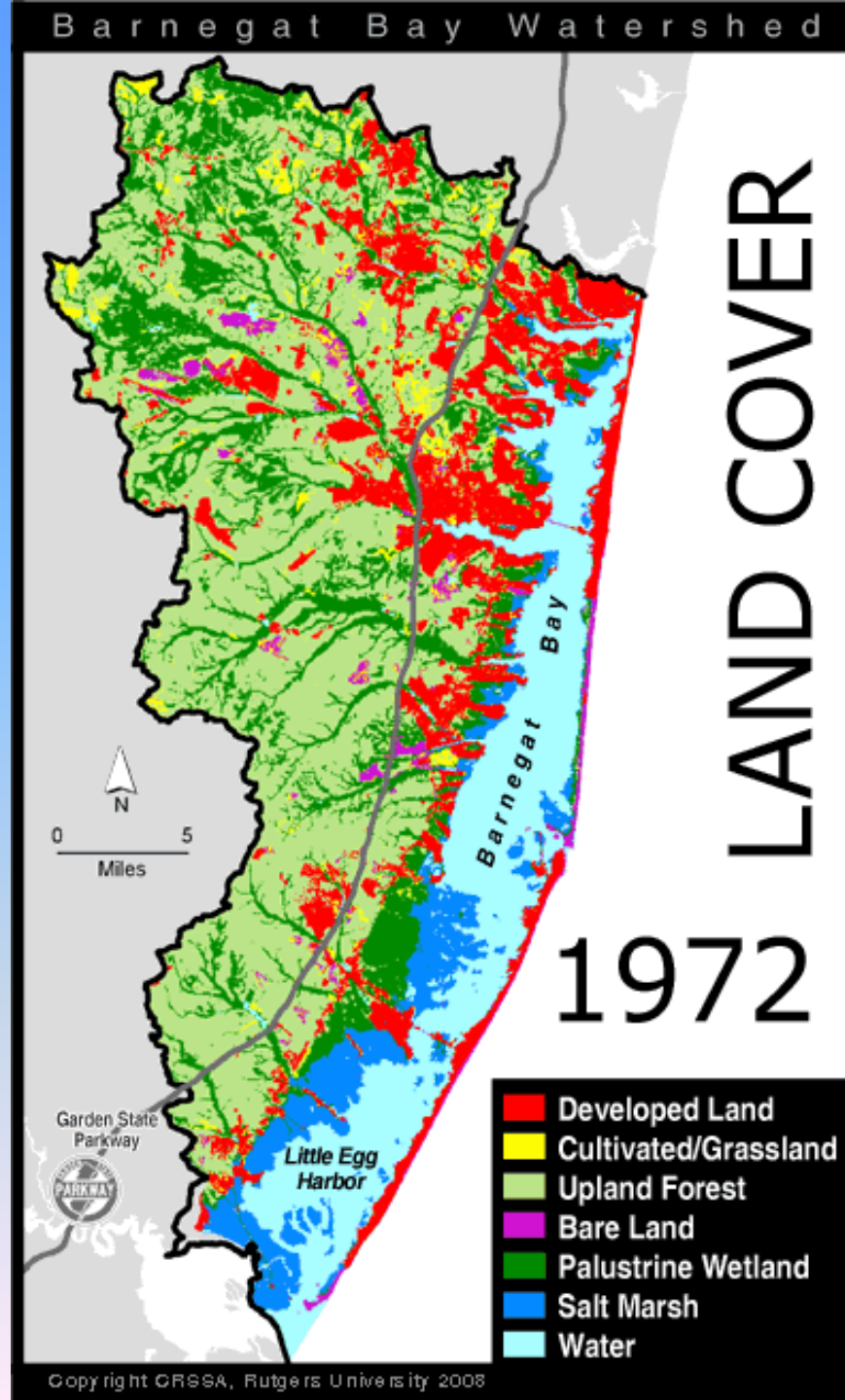
Change in Barnegat Bay Land Use at Forked River and Oyster Creek (1931 and 2011)



Land Use Change: the Driving Coastal Stressor

Over 1/3 of the BBEP watershed is developed or otherwise altered

- Changing surface runoff and groundwater flows
- Increased nutrient, chemical & sediment inputs
- Habitat loss, alteration and fragmentation



10(+) RESEARCH PROJECTS: 5 ENVIRONMENTAL MANAGEMENT AREAS

- A. Aquatic Life Use Assessment and Site-Specific Water Quality Criteria Development
- B. Characterizing Environmentally Sensitive Areas (ESAs)
- C. Natural Resource Assessment and Management (Sustainable Fisheries)
- D. Ecosystems-Based Management and Modeling
- E. Water Quality Modeling Support (Plan 7)

ENVIRONMENTAL MANAGEMENT CHARGE QUESTIONS PRESENTED TO RESEARCHERS...

- Focus of research: Develop environmental management tools for NJDEP.

ENVIRONMENTAL MANAGEMENT CHARGE QUESTIONS

A. Aquatic Life Use Assessment and Site-Specific Water Quality Criteria Development

Can biological indicators in estuaries identify the levels and causes of ecological impairment, and the extent to which impairment is related to the nutrients phosphorus and nitrogen?

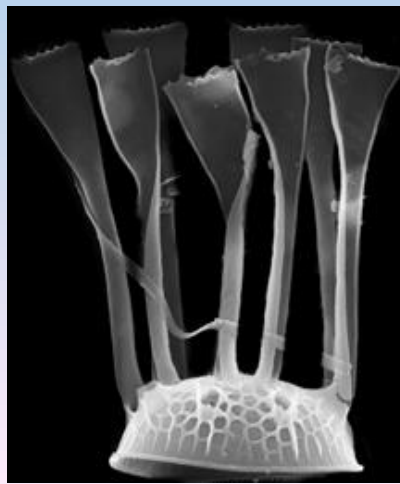
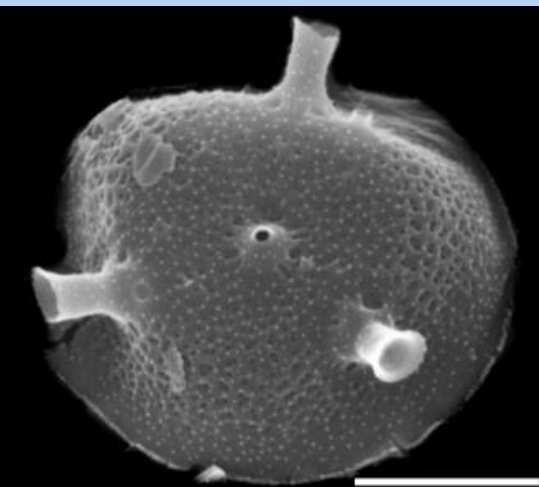
Specifically:

1. Does your research support the development of a scientifically defensible nutrient stressor-response model, specifically concentrations or load thresholds, including duration and frequency boundaries that would support a healthy aquatic community for the Barnegat Bay estuary?
2. Does your research support the development of indicators or models to assess and protect aquatic life?
3. Can the collection of data be reduced or streamlined from the research methodology in a cost-effective manner (e.g., fewer sites and/or sampling times) to support an annual routine monitoring and assessment protocol by the state?

1. Diatoms as Environmental Indicators in Barnegat Bay,

Marina Potapova, Academy of Natural Sciences of Drexel University

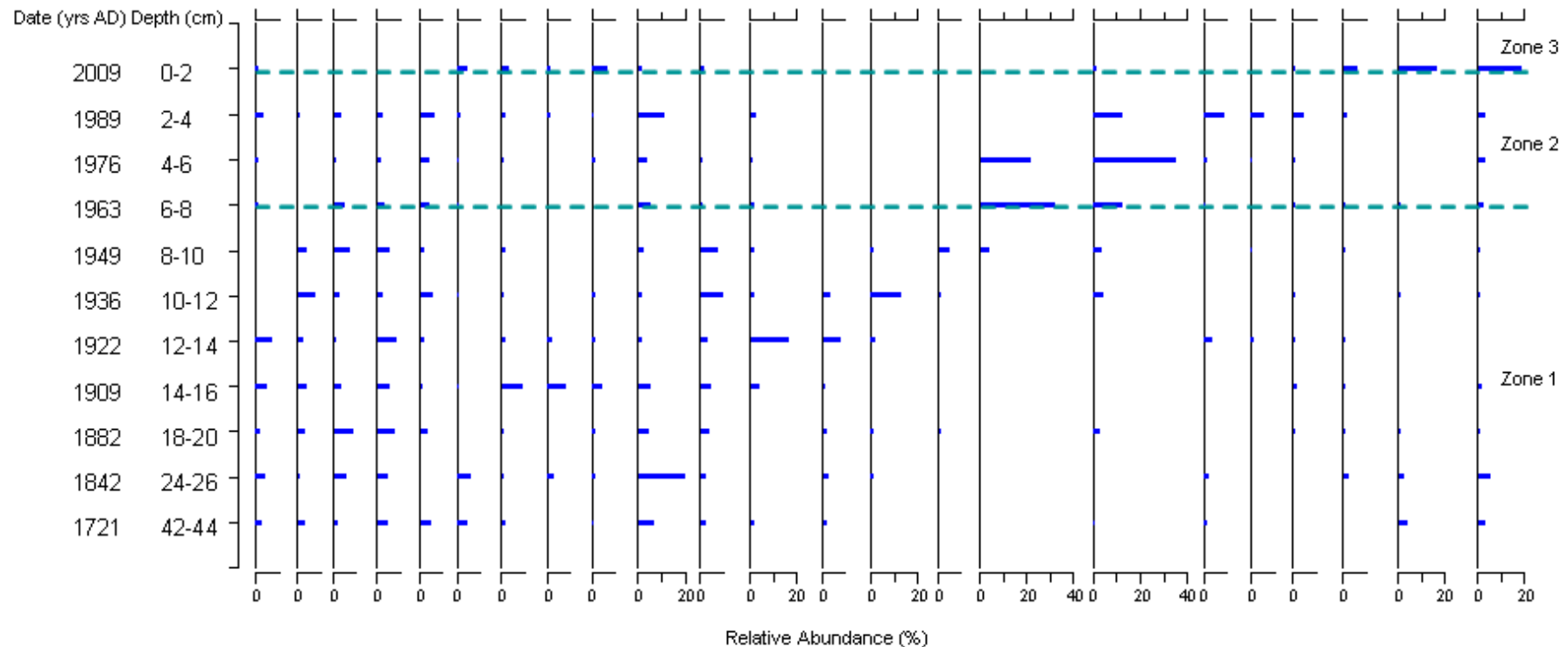
- Predictive diatom inference models constructed from 100 bottom samples for salinity, TP, TN, and chlorophyll A:
 - 1). in the water column and
 - 2.) for nitrogen in the sediments.
- “Reference” diatom assemblages inhabiting BBay marshes (mid 1700’s to present) identified from salt marsh cores.
- Cores show that **abrupt changes in diatom species occurred over time and were consistent with land use changes in the Bay.**
- **Salinity, sediment N, and organic matter biggest driver of changes;** diatom assemblages shifted over time towards increased abundance of N-tolerant and higher C-tolerant species.



Core dating - Cs
137/Pb210
chemistry,
pollen and
diatom analyses



Diploneis parma
Frustula weinholdii
Coconeis scutellum
Parallia sulcata
Tryblionella debilis
Navicula salinicola
Navicula cincta
Navicula digitoradiata
Navicula phyllepta
Navicula sp. 1 MUR DME
Caloneis sillicula
Diploneis smithii
Nitzschia vasta
Nitzschia nana
Pseudostaurosira
Melosira nummuloides
Luticola mutica
Diploneis oblongella
Seminavis sp. 1 MUR DME
Amphora interrupta
Planolithidium frequentissimum
Denticula subtilis

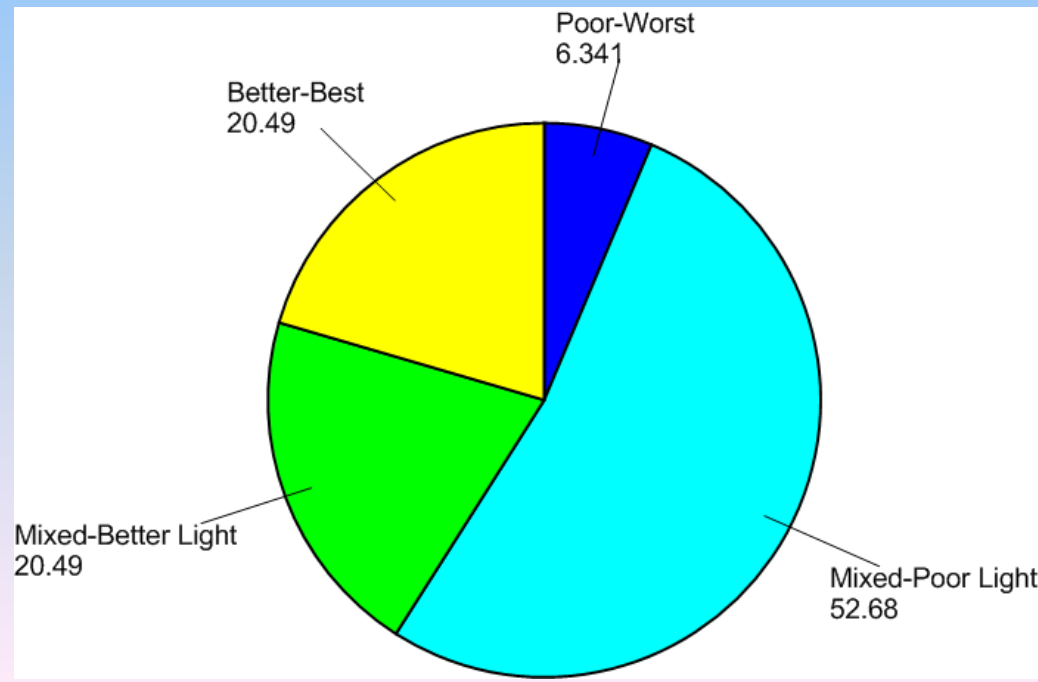


2. Baseline Characterization of Phytoplankton and Harmful Algal Blooms,

Ling Ren and Don Charles, Academy of Natural Sciences of Drexel University

- Identified phytoplankton species compositions and successions, including bloom patterns directly linked to nutrient loading (TP and TN).
- Developed a phytoplankton index of biotic integrity (P-IBI) for BBay (potential nutrient criteria)
- **Approx. 60% of the habitat** sampling events (205 samples collected between 2011 and 2013) were **classified as Poor and Mixed-Poor conditions**, indicating that present-day water quality is often undesirable
- Results: **Nutrient over-enrichment is causal factor in poor phytoplankton assemblages**, more so in summer.

Percentage of each major habitat category for samples (205) collected from 2011-2013 in Barnegat Bay.

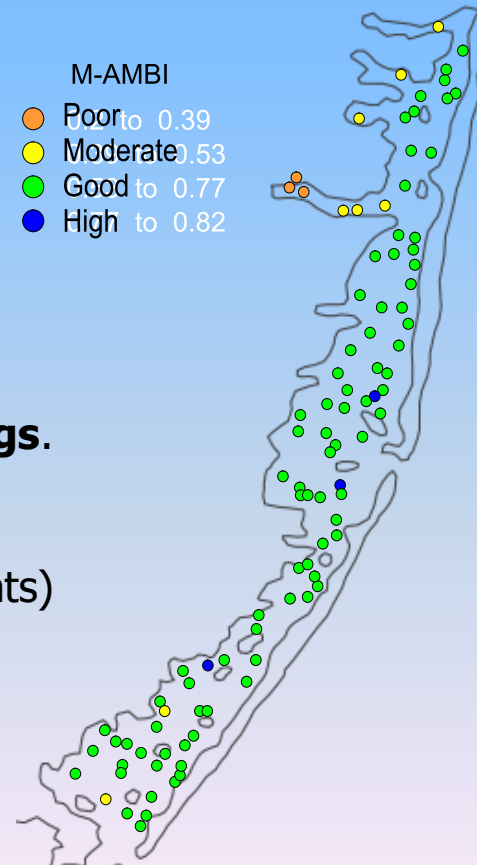


3. Benthic Invertebrate Community Monitoring and Indicator Development,

Gary Taghon, Judith P. Grassle, Charlotte M. Fuller, and Rosemarie F. Petrecca, Rutgers

AQUATIC LIFE CRITERIA:

- Evaluated 4 established sets of benthic invertebrate (in-bottom worms, clams and crabs) biological indices
- All 4 indices worked well for BBay, but **M-AMBI chosen as index of choice**
- **Average M-AMBI score for BBay = "Good"**, invertebrate data have characterized that substantial majority of the 100 sites sampled in BBay as "not degraded, good, or of high quality."
- Total nutrient (TN and TP) and TOC concentrations in sediments very low.
- **Further Evaluation Needed (i.e. DEP) to validate initial findings.**



NUTRIENT CRITERIA: (how much of the impacts are related to nutrients)

- Using the M-AMBI Index we explored nutrient criteria development in order to overcome the salinity gradient which can mask species responses to nutrients.

ENVIRONMENTAL MANAGEMENT CHARGE QUESTIONS

B. Natural Resource Assessment and Management (Sustainable Fisheries)

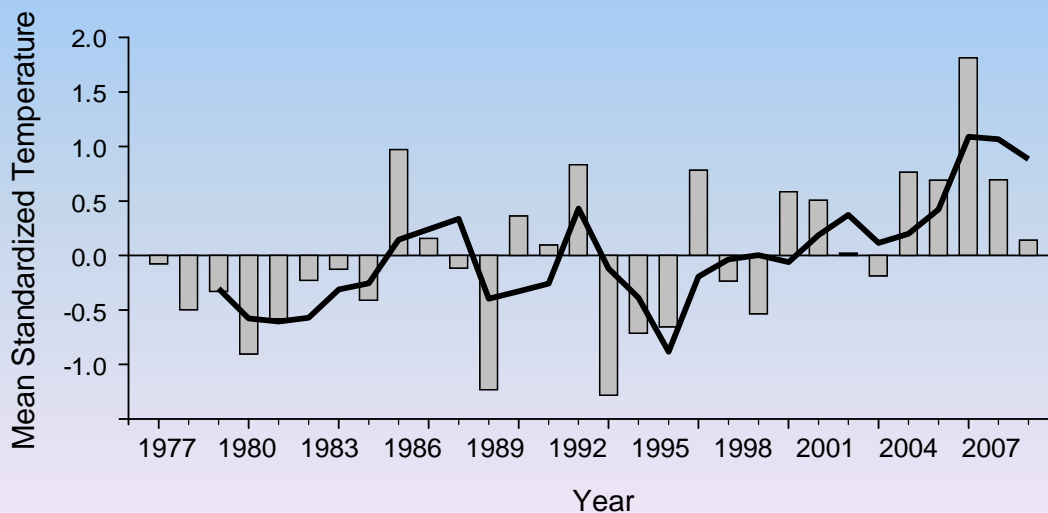
Has the increasing human population density and urbanization of the bay had an effect on the abundance and diversity of finfish and blue crabs?

Specifically:

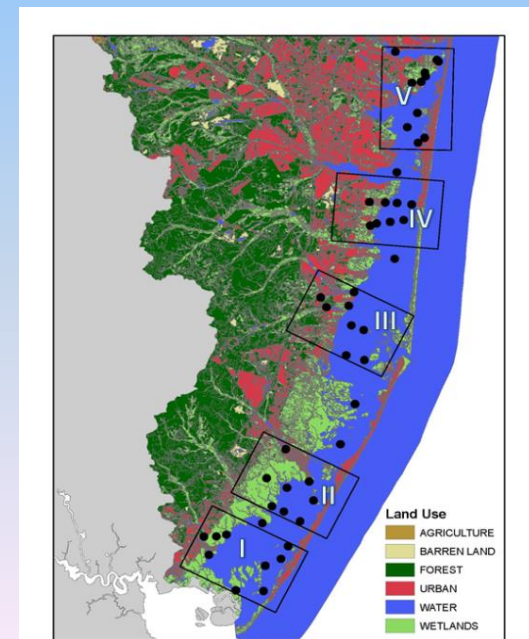
1. Do the major components of the fauna in the bay (finfish and crabs) respond to an urbanization gradient (BBay more urban in north, less so in south)?
2. Is there a documented change or loss of preferred habitat in the bay that may have effects on fish and crab abundance and distributions?
3. What is the long term perspective on sustainable commercial fisheries in the bay?
4. What is the long term ecological perspective for a balanced food web, carbon cycling, habitat resilience, etc.?

4. Assessment of Fishes/Crab Responses to Human Alteration of Barnegat Bay, Kenneth Able, Tom Grothues and Paul Jivoff; Rutgers and Rider Universities.

- **No Urbanization Gradient:** Fish trawl and crab trap results (2012-2013) show no obvious changes in fish distribution and abundances in the Bay, which is more urban in the north and less so in the south.
- **However, Changes in Fauna are Occurring.** Comparisons with similar sampling gear (otter trawl) from early (late 1970s/ early 1980s) and late (2012/2013) indicate that the fish fauna has changed.
- **Indication of Climate Change.** Fish faunal response over these decades suggests some resident and cool-water migrant species are less abundant and have been replaced by warm-water migrants.



Annual Variation in Temperatures for Great Bay (1976 – 2007)



5. Hard Clam Survey in Barnegat Bay-Little Egg Harbor Estuary,

Kira Dacanay, NJDEP Bureau of Shellfisheries

- 2011 Little Egg Harbor Bay Survey - Estimated 86 million clams, a 32% increase from 2001 but still a **57% decline from 1980s**
- 2012 Barnegat Bay Survey - Estimated 136.7 million clams, which represents an **approximately 23% decrease in the standing stock** vs. 177.3 million clams estimated in the 1985/86.
- 2013 Re-Survey - No significant difference in hard clam abundance or mortality before and after Superstorm Sandy.

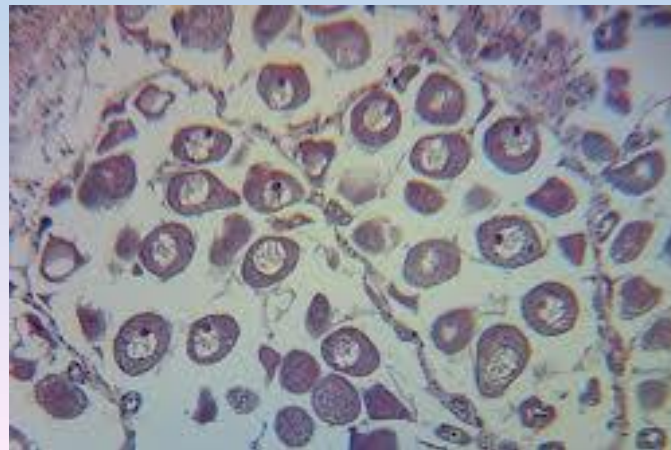
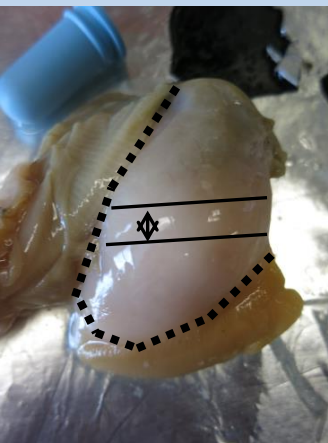
6. Assessment of summer-fall conditioning of hard clams in the Barnegat Bay estuary in relation to clam size and environmental conditions,

Monica Bricelj, John Kraeuter and Gef Flimlin, Rutgers

- Hard Clam shell growth in BB-LEH is comparable to other mid-Atlantic coastal ecosystems.
- **Growth rates** of juvenile clams occur in relatively undeveloped, protected areas of the Bay; **greatly influenced by food quality, salinity, and water temperature.**

Two Sites Compared (IBSP vs. SICZ):

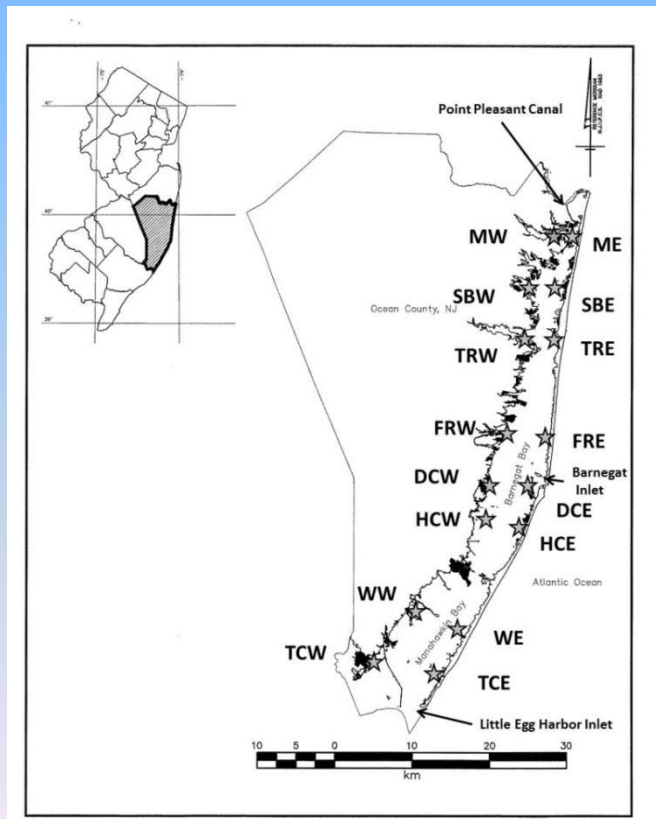
- **Reproductive condition was significantly greater at IBSP than SICZ**, which can be due to higher fluctuation in salinity and temperature at SICZ.
- Reproductive allocation was significantly lower for littlenecks than larger clams at both study sites.
- Result suggests that **the minimum size for legal harvesting may not allow a significant contribution to the population's reproductive output.**



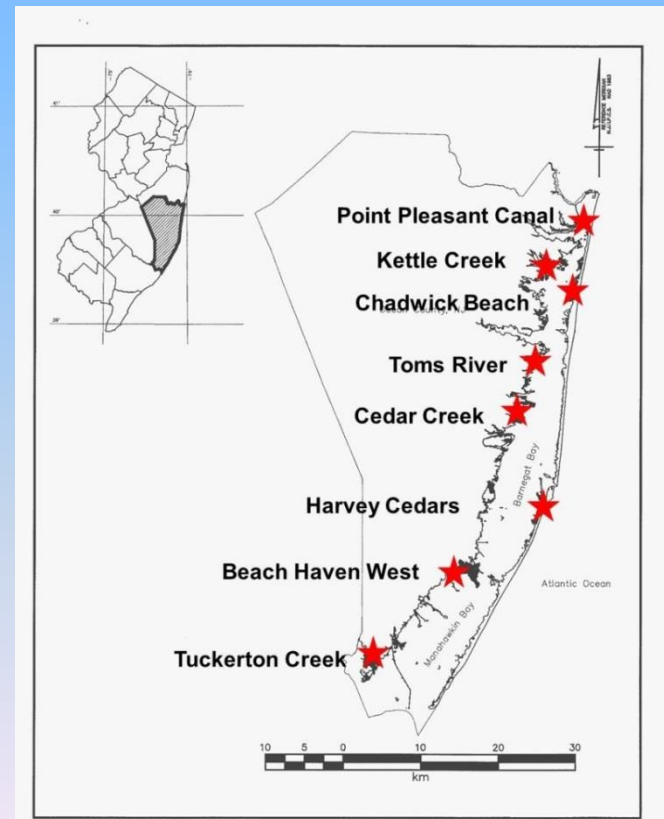
7. Assessment of the Distribution and Abundance of Stinging Sea Nettle, Paul Bologna and Jack Gaynor, Montclair University

Why do stinging sea nettles seem to be on the increase recently in Barnegat Bay?

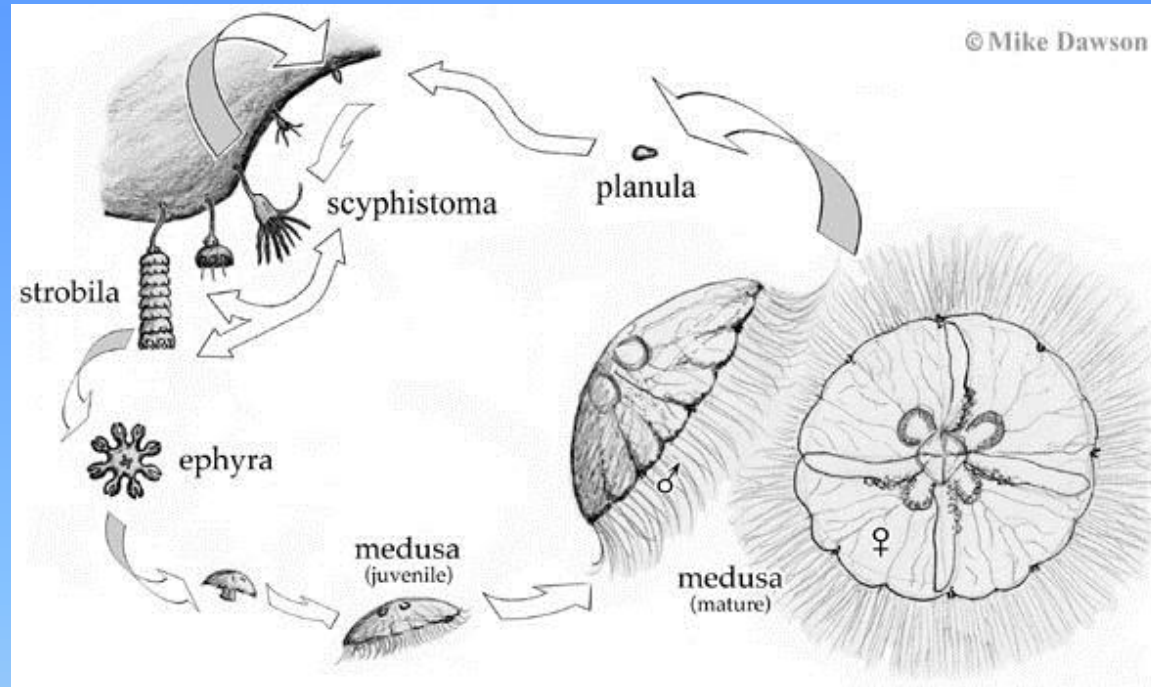
Evaluate the Spatial and Temporal Distribution of Jellyfish in All Lifecycles



Yr 1 Bay Wide Sampling Stations



Yr 2 Lagoon Sampling Stations



RESULTS (Sea Nettle Study):

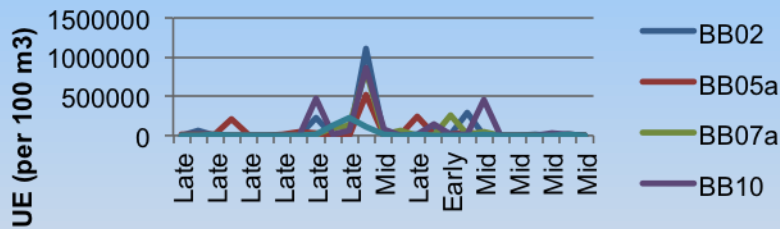
- **Polyps need hard surfaces for development** (Recent increase in plastic and vinyl bulkheads vs. treated woods)
- Sea nettles can live in degraded environments (low DO, high nutrients = lagoons)
- **Boating lagoons are important areas for polyp settling and attachment.**
- Evidence that sea nettle blooms are being driven by BOTH top-down processes (predation, competition) and bottom-up (eutrophication effects like anoxia) drivers in Barnegat Bay.
- **Sea Nettles assuming Top Planktonic Predator Status;** consume numerous taxa including commercially important fish, crab, and bivalve species
- Sea Nettles appear to be expanding their range south into Little Egg Harbor (larva).

8. Baseline Characterization of Zooplankton in Barnegat Bay,

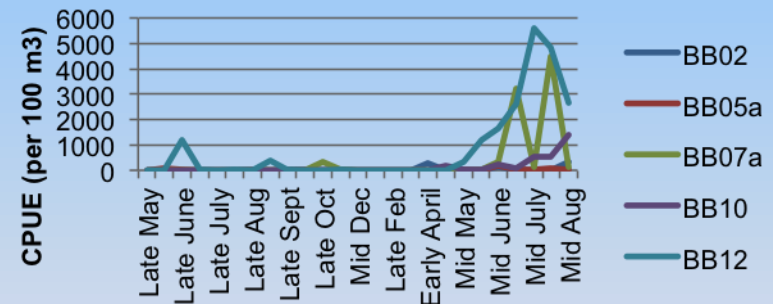
Jim Nickels and Ursula Howson Monmouth University

- Zooplankton such as copepods = ACARTIA (shrimp-like crustaceans) are important components of the zooplankton during spring and fall blooms throughout the bay.
- **Northern BBay characterized by higher N and CHL a, but has the lowest species diversity of zooplankton and ichthyoplankton in the Bay.**
- Groups such as decapods (crabs) and bivalves (hard clams) exhibit discrete spawning pulses during certain times of the year, and are almost absent from the plankton otherwise.
- **Direct and/or indirect weather patterns greatly affect zooplankton abundance in BBay.**

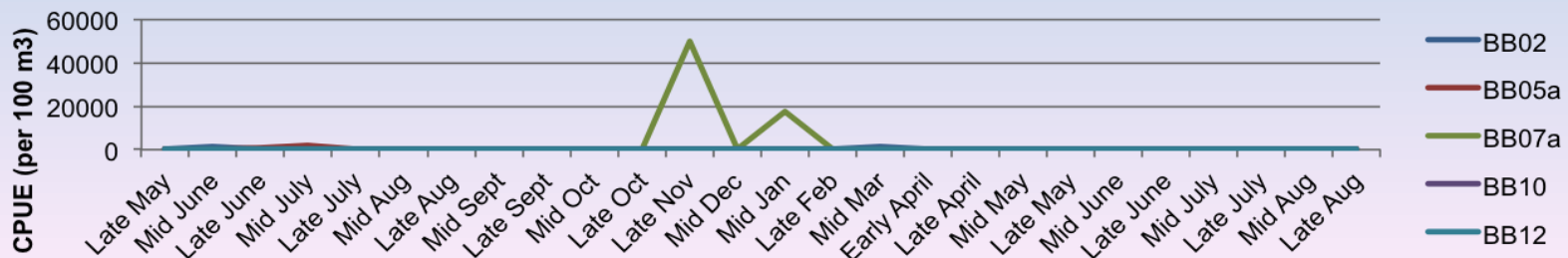
Acartia (copepod)



Decapoda



Pelecypoda (bivalves)



ENVIRONMENTAL MANAGEMENT CHARGE QUESTIONS

C. Ecosystems-Based Management and Modeling

How can an ecosystem model for Barnegat Bay assist NJDEP in developing an Ecosystem-Based Management (EBM) strategy for natural resource management and decision-making?

Specifically:

1. How can an EBM model be used to test hypothesis about:
 - Effect of decreasing nutrient loads to BBay on important recreational and commercial fish (finfish, shellfish and blue crab)?
 - Biota effects from closure of Oyster Creek Nuclear Generating Station in 2019 (due to changes in abundance, competition, predation among species)?
 - Development of fishery management plans related to hard clam and blue crab?
2. Can the model separate and integrate simultaneous perturbations in the model system (e.g., nutrient flows and fish harvest)?
3. Will the model identify key species to be included in future monitoring plans?

9. Multi-Trophic Level Modeling of Barnegat Bay, Olaf Jensen, Heidi Fuchs and Jim Vasslides, Rutgers

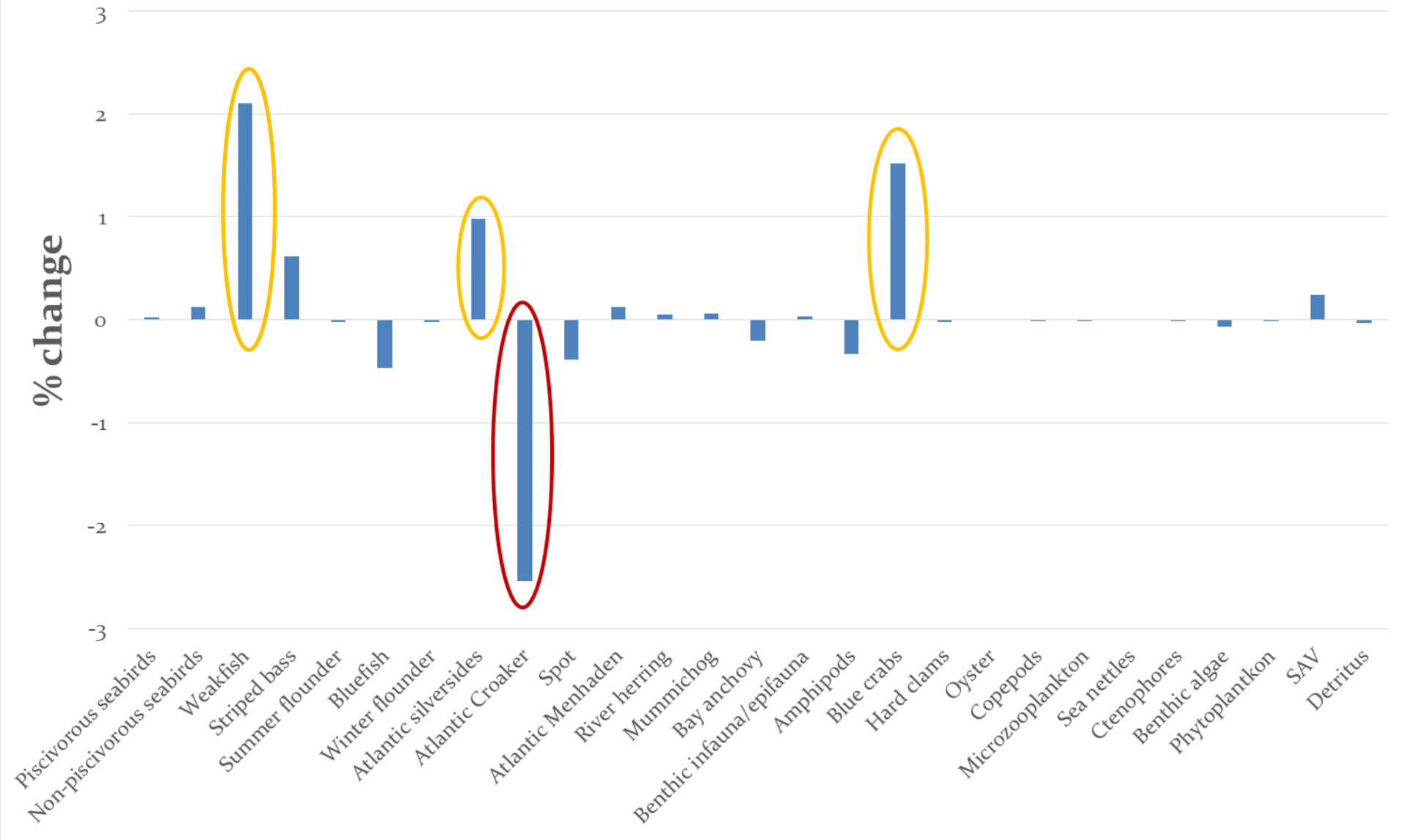
Ecosystem-Based models of food web biomass are typically based on literature values, however...

Data from all 10 studies and years (2012, 2013, 2014) used to build a regional model of BBay biomass and food web dynamics.

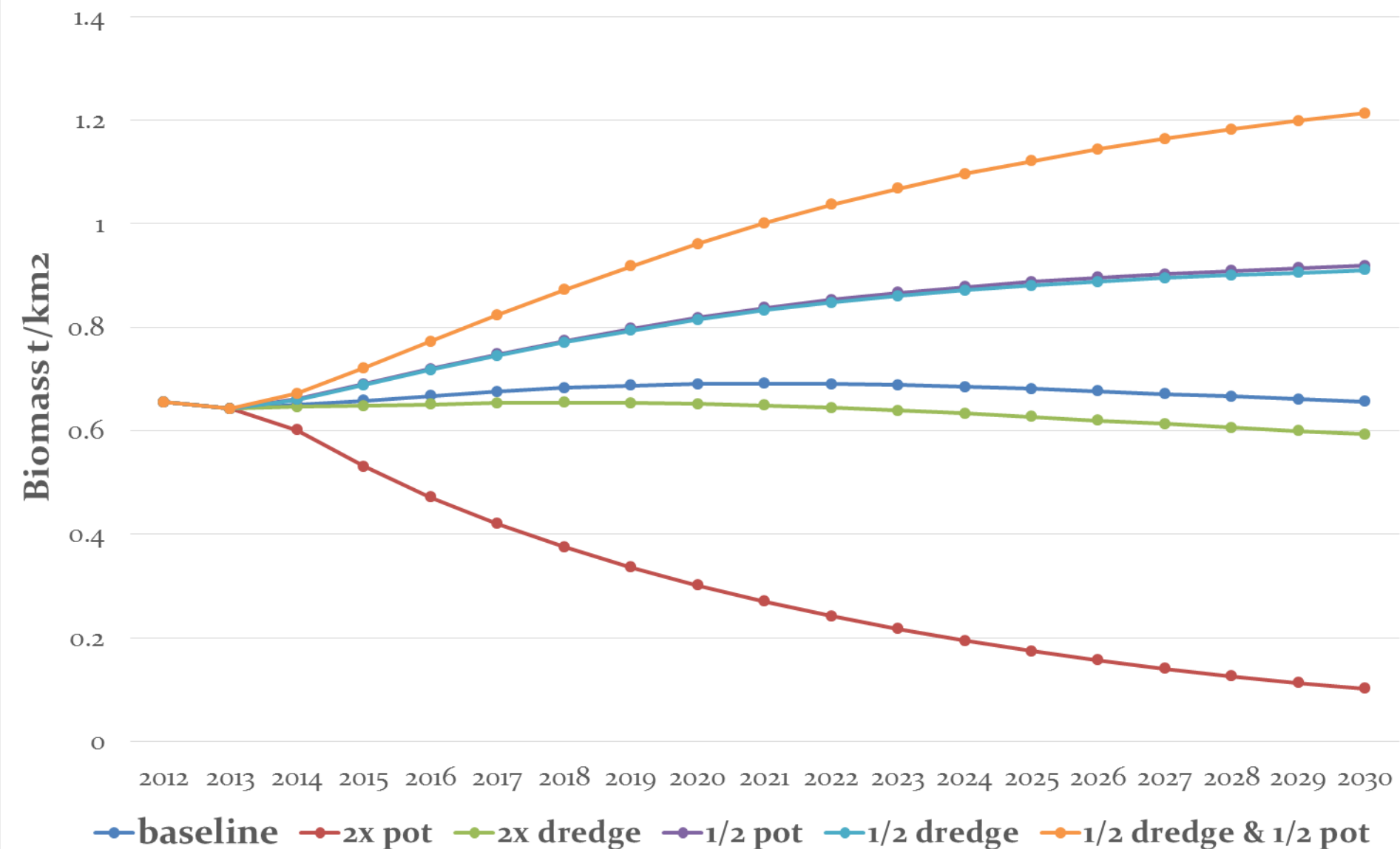
We then used the model for ecosystem hypothesis testing of stressor release scenarios upon fisheries in BBay such as:

- **Closure of Oyster Creek Nuclear Generating Station** (i.e., release of cooling water intake impingement and entrainment effects on zooplankton)
- **Potential implementation of species-specific fishery management plans** (e.g., hard clam and blue crab)
- Upstream nutrient reductions 20% and 40% on phytoplankton and cascading food web effects

OCNGS closure scenario



Blue crab harvest control



Baseline Dredge– 44 MT

Baseline Pot – 210 MT

ENVIRONMENTAL MANAGEMENT CHARGE QUESTIONS

D. Characterizing Environmentally Sensitive Areas (ESAs)

Are there differences in habitat features, abundance and/or distribution/diversity of key species or other environmental characteristics in the 16 delineated Environmentally Sensitive Areas (ESAs) in Barnegat Bay?

Specifically:

1. Is there a greater risk to the ESA habitats or their biota due to boating impacts compared to similar areas outside the ESAs?
2. Are their indicator species or groups of species useful in a routine monitoring program to continually assess the biological integrity of the ESAs?
3. Do the data support the development of a multi-metric assessment index for future monitoring and management of the ESAs?

10. Ecological Evaluation of Sedge Island Marine Conservation Area (SIMCZ),

Paul Jivoff, Rider University

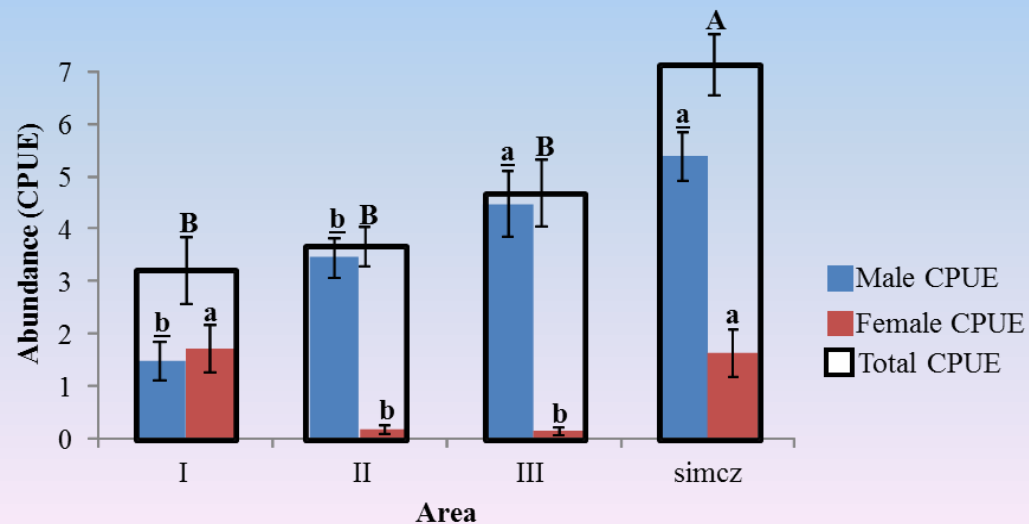
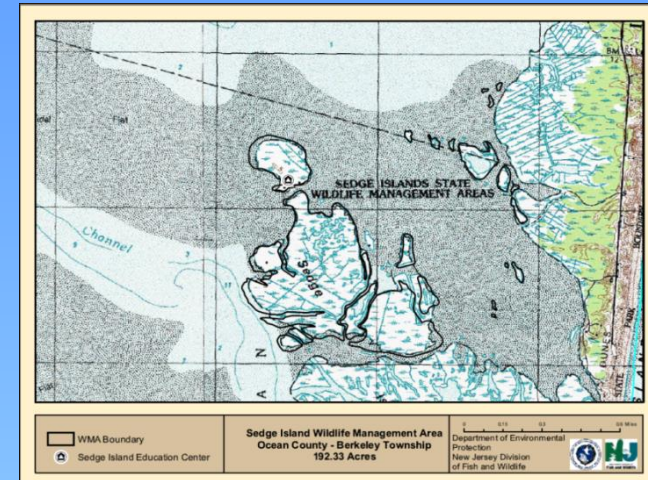
SIMCZ: Established in 2001 to conserve and protect from commercial fishing and personal water craft impacts.

Objectives this study:

- Are habitats inside SIMCZ equivalent to outside?
- Use the blue crab as indicator species

RESULTS:

- **SIMCZ - Greater abundance of male crabs/larger males, and egg-bearing (spawning) females** than mid- and western-bay locations outside the SIMCZ.
- Throw trap sampling for fish and crabs indicated that two economically important fish species (winter and summer flounder) were more abundant inside vs. outside the SIMCZ.
- **SIMCZ - Serves as a refugia for various species at critical life history stages.**



11. Evaluation of Environmentally Sensitive Areas (ESAs) to Water Craft Impacts, Richard G. Lathrop Jr. and Edwin Green, Rutgers

Barnegat Bay supports numerous recreational activities, which can harm SAV beds, marine life, erode shorelines, and disturb nesting shorebirds.

ESAs: Due to watercraft impacts, Environmentally Sensitive Areas (16) were delineated using best available data (e.g., SAV beds, shellfish beds, colonial shorebird/raptor nesting and foraging areas, etc.)

GOAL: Use Plan 9 data and other data sets to add more statistical rigor to these ESA designations.

RESULTS TO DATE:

- **Two statistically significant indicators** exist predicting differences in habitat between ESA's and non-ESA areas:
 - 1. Bird Habitat Quality**
 - 2. Percent of Bottom with SAV**
- Metrics are being further addressed for ESA multi-metric index development (Study to conclude early 2016).



Boat Scarring in Barnegat Bay

Boat Scarring Natural Color 2012

ESAs

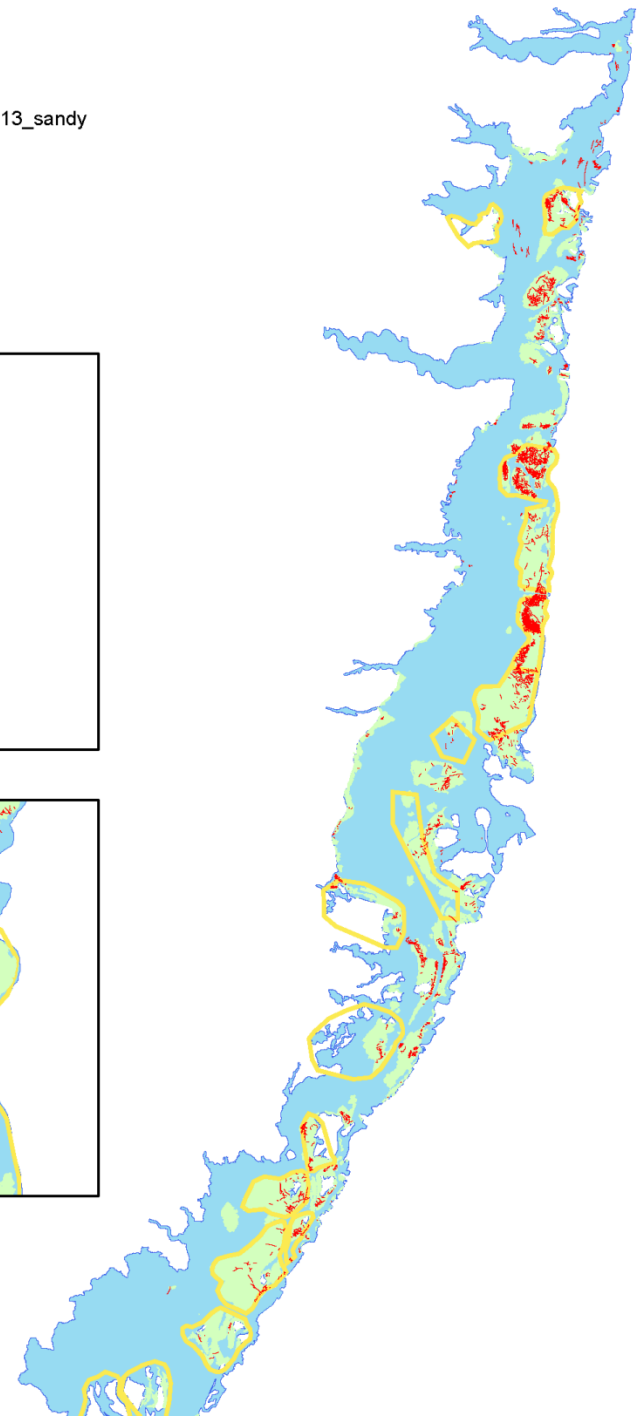
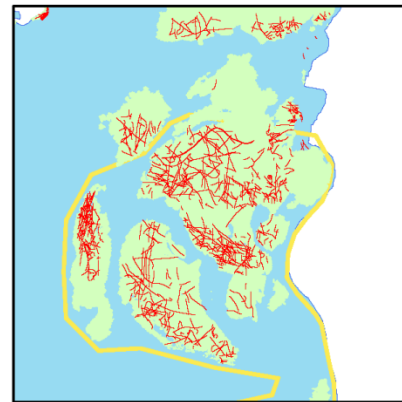
Legend

Boat_Scar_02070809101213_sandy

ESAs

bbleh_sav09NJSP

bbleh_sav09NJSP



E. WATER QUALITY MODELING SUPPORT

12. Salt Marsh Study - Nutrient Histories in Barnegat Bay from Historical Cores,

David Velinsky, Don Charles, Mihaela Enache, Academy of Natural Sciences of Drexel University, Christopher Summerfield, University of Delaware

- Over 28% of Barnegat Bay's salt marshes have been lost to development.
- **Salt marshes remove over 80% of the estimated 7×10^5 kg/year nitrogen load to Barnegat Bay.**

13. Salt Marsh Denitrification Study, David Velinsky, Tracy Quirk, Jeff Cornwell, and Mike Owens; Academy of Natural Sciences of Drexel University, Patrick Center; Louisiana State University, and University of Maryland, Center for Environmental Science

- A significant amount of this sequestered nitrogen is then converted to nitrogen gas and returned to the atmosphere through microbial action.

14. Phosphorus Dynamics in Barnegat Bay Sediments,

David Velinsky and Bhanu Paudel, The Academy of Natural Sciences of Drexel University

- Highest loading coming into the northern bay from more urban areas
- However, **higher concentrations of nitrogen are found in the north while higher phosphorus concentrations in the south.**
- **“Phosphorus sink”: Sediments are large reservoir of P, but not a source of phosphate to the water.**
- Gradient of phosphate in Bay confirmed
 - Higher sediment P in central and south Bay
 - Substantial water-column production of phosphate in central and south Bay in July under anoxic conditions (which does not happen often)

Future research: How might water column geochemical processes and/or bottom sediment geochemical processes play a role in nutrient transport and eutrophic condition?

Ultimate Goal:

Develop a Barnegat Bay Management and Action Plan

ASSESSMENT & RECOMMENDATIONS:

Initial Comprehensive Assessment: (Complete) November 2015 management briefing (includes Communication Plan and Action Plan).

Communications: (Ongoing) DEP/BBP Stakeholder Forum: November 17, 2015 at Ocean County College (Complete)

Final Comprehensive Assessment: (Ongoing) Merge research and WQ modeling of BBay (Plan 7) and management scenarios by August 2016.

